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Goodwin, PC, Morrissey, MC, Omar, RZ, Brown, M, Southall, K and McAuliffe, TB (2003) Effectiveness of supervised physical therapy in the early period after arthroscopic partial meniscectomy. *PHYSICAL THERAPY*, 83 (6). pp. 520-535. ISSN 0031-9023

Downloaded from: <https://e-space.mmu.ac.uk/80127/>

Publisher: American Physical Therapy Association (APTA)

DOI: <https://doi.org/10.1093/ptj/83.6.520>

Please cite the published version

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Effectiveness of Supervised Physical Therapy in the Early Period After Arthroscopic Partial Meniscectomy

Background and Purpose. Controversy exists about the effectiveness of physical therapy after arthroscopic partial meniscectomy. This randomized controlled trial evaluated the effectiveness of supervised physical therapy with a home program versus a home program alone. **Subjects.** Eighty-four patients (86% males; overall mean age=39 years, SD=9, range=21–58; female mean age=39 years, SD=9, range=24–58; male mean age=40, SD=9, range=21–58) who underwent an uncomplicated arthroscopic partial meniscectomy participated. **Methods.** Subjects were randomly assigned to either a group who received 6 weeks of supervised physical therapy with a home program or a group who received only a home program. Blinded test sessions were conducted 5 and 50 days after surgery. Outcome measures were: (1) Hughston Clinic questionnaire, (2) Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) and EuroQol EQ-5D (EQ-5D) questionnaires, (3) number of days to return to work after surgery divided by the Factor Occupational Rating System score, (4) kinematic analysis of knee function during level walking and stair use, and (5) horizontal and vertical hops. **Results.** No differences between groups were found for any of the outcomes measured. **Discussion and Conclusion.** The results indicate that the supervised physical therapy used in this study is not beneficial for patients in the early period after uncomplicated arthroscopic partial meniscectomy. [Goodwin PC, Morrissey MC, Omar RZ, et al. Effectiveness of supervised physical therapy in the early period after arthroscopic partial meniscectomy. *Phys Ther.* 2003;83:520–535.]

Key Words: *Arthroscopy, Home program, Randomized controlled trial, Therapeutic exercise.*

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Meniscal injuries are reported to be the most common injury sustained by athletes, but sports injuries account for only 30% of all meniscal lesions.¹ In the United Kingdom, medical management for a torn or damaged meniscus usually consists of arthroscopic partial resection, followed by a 2- to 6-week outpatient follow-up by the surgical team. Follow-up is used to detect postoperative knee complications and to assess the eradication of presurgical symptoms and the progression of recovery of the knee toward its premorbid level. Although meniscectomy appears to be effective, patients who have had an arthroscopic partial meniscectomy often initially experience knee swelling, pain, and loss of range of motion

(ROM), and they may have increased joint laxity and osteoarthritis in the long term.²⁻⁶

Supervised rehabilitation after surgery has been advocated and studied as part of short- and long-term follow-up after arthroscopic partial meniscectomy.⁷⁻⁹ Durand et al¹⁰ compared 17 patients who had undergone arthroscopic partial meniscectomy with 22 matched male subjects without known knee pathology during walking and ascending and descending stairs. Eight weeks after their surgery, 18% of the patients experienced pain at rest, 10% still had knee effusions, and 41% showed restricted knee flexion. Differences were found between the intervention group and the

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Mr Goodwin, Dr Morrissey, Dr Omar, Mr Brown, and Ms Southall provided concept/idea/research design. Mr Goodwin, Dr Morrissey, Mr Brown, and Ms Southall provided writing. Mr Goodwin, Dr Morrissey, Mr Brown, and Ms Southall provided data collection. Mr Goodwin, Dr Morrissey, and Dr Omar provided data analysis and fund procurement. Mr Goodwin and Dr Morrissey provided project management. Mr McAuliffe provided subjects. Ms Southall provided facilities/equipment, and Mr Brown and Ms Southall provided institutional liaisons. The authors thank orthopedic surgeons Matthew Barry, Thomas Bucknill, Mustafa El-Zebdeh, David Goodier, John Ireland, John B King, Kin C Kong, Mandeep Lamba, Benigmus E Okafor, and Vairavipillai Siva and physical therapists Jane Dredge, Salu Fellows, Jo Jones, Maria Klarneta, Philippa Knight, and Dylan Morrissey for their support of this study.

This study was approved by the ethics committees of the University of East London and the East London and City Health Authority (ELCHA).

This study was supported by a grant from the National Health Service Executive, London Regional Office, Responsive Funding Programme and an Educational Award from the Hospital Savings Association.

This article was submitted December 27, 2001, and was accepted November 22, 2002.

control group in terms of single ipsilateral-to-contralateral limb-support ratio (95% for the intervention group, 100% for the control group) during gait and the time taken to complete 2 steps (\bar{X} =1,478 milliseconds [SD=192] for the intervention group, \bar{X} =1,318 milliseconds [SD=121] for the control group) and cadence (\bar{X} =82 steps/min [SD=11] for the intervention group, \bar{X} =92 steps/min [SD=8] for the control group) during stair descent, which continued up to 8 weeks after surgery. These patients were described by Durand et al as not managed with supervised physical therapy. Durand et al, however, referred to evidence by Moffet et al¹¹ showing that physical therapy consisting of a home exercise program combined with 9 supervised treatments (including electrotherapy, ice, and compression followed by isometric and isokinetic exercises and bicycle ergometry) promotes faster recovery from the deficits found in their study.

A knee extensor strengthening program was suggested by Moffet et al,¹² who reported that decreased muscle activity caused a decrease in knee extensor work (work was measured during maximal voluntary isokinetic contractions). They contended that deficits of more than 25% 3 weeks after surgery may be used to estimate stair ascent performance. In the study by Moffet et al, the postoperative work deficit of the operated lower extremity was established as a percentage of the knee extensor work of the contralateral lower extremity in 31 male subjects. Patients with a work deficit of less than 25% ascended the stairs normally, and those with deficits greater than 25% showed the greatest changes.

Matthews and St-Pierre¹³ advocated use of a supervised isokinetic knee exercise program in the first 3 months after surgery. Twenty-two patients were measured before surgery and at 2-week intervals up to 12 weeks after surgery. With a home exercise program that did not involve resistance exercises, quadriceps femoris muscle torque (measured at 60°, 120°, 180°, and 240°/s) returned to preoperative levels at between 4 and 6 weeks after surgery, but did not reach that of the uninjured lower extremity even at 12 weeks after surgery.

Roos et al¹⁴ used the Knee Injury and Osteoarthritis Outcome Score, the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) questionnaire, and the Lysholm Knee Scoring Scale to measure knee function and quality of life in 74 patients compared with reference scores from the general population and preoperative data. Although improvements from preoperative values were seen, postoperative values also showed that disability and handicap remained compared with the general population even up to 14.4 weeks after surgery.

The deficits in knee extensor work, function, and other variables occurring after partial meniscectomy indicate that exercise programs may be useful for these patients. Several randomized controlled trials have examined the benefits of exercise after this type of surgery. Using the Noyes Knee Rating Questionnaire preoperatively and 7, 14, and 42 days postoperatively, Birch et al¹⁵ compared 120 patients who were randomly assigned to 1 of 3 groups: a group who received physical therapy (\bar{X} =3 treatment sessions), a group who received nonsteroidal anti-inflammatory drugs, and a control group. Subjects in the group who received physical therapy were seen during the afternoon after surgery and were allowed to return home when they were able to do straight leg raises, demonstrate the home exercise program, and walk fully weight bearing with minimal discomfort. Subjects were then treated daily until they reached full functional recovery. Content of the home or supervised therapy program was not detailed. No differences in knee function scores were found among the groups.

Knee extensor work and a knee function questionnaire were used in a randomized controlled trial by Moffet et al¹¹ in which subjects who participated in 9 physical therapy sessions and a home exercise program (n=15) were compared with a control group who received only general advice (n=16). The home program consisted of 2 main sections, one for the first week and the second for the second and third weeks postoperatively. Exercises consisted of ankle movements, knee mobility exercises, isometric contractions of the quadriceps femoris muscles, and straight leg raises. A booklet was issued on the progressive use of crutches, ice therapy, and limb elevation. The second section consisted of progression of exercises with 0.45-kg (1-lb) weight increments and isotonic quadriceps femoris muscle contractions. The supervised therapy program was initiated on average 2.3 days after surgery and consisted of 2 phases. In the first week postoperatively, the initial phase concentrated on reducing knee pain and effusion, regaining knee mobility, and strengthening the knee flexors and extensors using isometric exercises at 30 and 60 degrees of knee flexion. The second phase began about 10 days after surgery. It included isokinetic exercises using a Cybex II dynamometer* at 60°, 120°, and 200°/s through full knee ROM and bicycle ergometry starting at 5 minutes per session and increasing up to 30 minutes per session. Knee extensor work at 30°/s improved after surgery in the intervention group compared with the control group. Knee extensor work at 180°/s decreased in both groups after surgery, but to a greater degree in the control group. No differences were found between the 2 groups with regard to function as measured with the Lysholm questionnaire.

* Cybex, 2100 Smithtown Ave, Ronkonkoma, NY 11779.

Jokl et al¹⁶ compared 30 patients assigned to either a group who received a home exercise program or a group who received physical therapy (\bar{X} =13.5 treatment sessions). The home exercise program included quadriceps femoris muscle setting and 3 sets of 10 straight leg raises without weights on the first postoperative day. Once subjects were able to weight bear without crutches, knee ROM exercises were started from 45 degrees to full extension as well as hamstring muscle curls and hip adduction and abduction exercise in a supine position. After 2 days of exercising without weights, subjects began isotonic exercises with a weight boot adding 0.45-kg increments per day or as tolerated. Low-impact sports (eg, slow jogging) were encouraged once 11.34 kg (25 lb) was achieved in the knee extension exercises, and full athletic activity was allowed once 20.41 kg (45 lb) was achieved. The supervised regimen began 5 days postoperatively and included whirlpool, instruction on knee ROM exercises, electrical stimulation of the quadriceps femoris muscles, quadriceps femoris muscle setting, straight leg raises, and hip extension exercises. Compression dressings were used when a knee effusion was judged present. Hamstring muscle curls, leg presses, quadriceps femoris muscle extension exercises, and bicycle ergometry were introduced, with intensity and duration of exercises progressed as quickly as were tolerated. Whirlpool was continued as long as knee ROM was limited, and electrical stimulation was continued until the subjects were judged to have good muscle tone during a quadriceps femoris muscle set.

Knee function was assessed using a questionnaire, time taken to return to work, and knee extensor torque (measured at 60°, 120°, and 180°/s with an isokinetic dynamometer). No differences were detected at 2, 4, and 8 weeks postoperatively for the questionnaire and the other outcome measures. Vervest et al¹⁷ compared a group who received standard written and verbal postoperative advice with a group who received physical therapy. The standard written and verbal advice was aimed at recovery of activities of daily living, but its content was not described. Subjects in the intervention group received 9 exercise sessions of 30 minutes' duration over a 3-week period according to a dynamic protocol supervised by the authors. The advice given to the control and intervention groups was not described in any further detail. Ten patients in each group were tested 7, 14, 21, and 28 days after surgery. From an array of outcome measures (height of one-leg vertical hop, distance of one-leg horizontal hop, Tegner scale score, Lysholm questionnaire score, Sports Activity Rating Scale, Factor Occupational Rating Scale (FORS), satisfaction with treatment, and function and pain) the intervention group did better than the control group on the Sports Activity Rating Scale. Over 4 weeks, the subjects in the control group had not improved their sports activity

score of 28/100 (no sports possible), whereas the intervention group improved from a score of 30 to a score of 48 (activities equal to running, cycling, and swimming 1–3 times per month). Subjects who received physical therapy also made greater improvements over the treatment period as compared with subjects in the control group on the single-leg vertical hop test (11.4 cm versus 1.5 cm, respectively) and the horizontal hop test (56.5 cm versus 7.4 cm, respectively).

We believe that small samples,^{11,15–17} lack of double blinding^{11,15–17} and standardization,^{15,17} and methodological weaknesses¹⁵ limit the conclusions that can be drawn from these randomized controlled trials, in which the results seem to be contradictory.¹⁸ In these studies, outcome measures often consisted of small changes in knee extensor torque and activity without considering outcomes such as quality of life, something that Roos et al¹⁴ contended should be part of any assessment following arthroscopic partial meniscectomy. The purpose of our study was to assess the benefits of written and verbal advice plus an intensive course of physical therapy consisting of an early period to decrease pain and swelling and to increase joint ROM, a middle period to increase muscle force and joint position sense, and a late period focused on advanced exercises compared with treatment consisting of written and verbal advice alone in the early period after arthroscopic partial meniscectomy. Our goal was to include outcome measures of importance to patients such as lower-extremity function and quality of life and sufficient numbers of subjects to allow generalizable results. Our hypothesis was that the group who received supervised physical therapy would exhibit greater improvements in knee function and quality of life during the early period after partial meniscectomy than the group who did not receive this intervention.

Materials and Methods

Subjects

Prior to data collection, a sample size estimation was calculated in order to formulate a sample size target for the study. This calculation was based on existing data¹⁰ rather than on guesses as to effect size. The calculation also was based on an outcome measure that would be considered important. These 2 criteria led to our use of the length of time from surgery to return to work as an outcome measure. Due to the high variability in this outcome,¹⁰ a large effect size (10 days) was used for sample size calculation. To detect an average difference of 10 days between the 2 groups with a .05 level of significance and 90% power and assuming a standard deviation of 19 led to a target sample size of 152 subjects. For ethical reasons, however, an interim analysis was carried out at the halfway point of data collection (ie, to

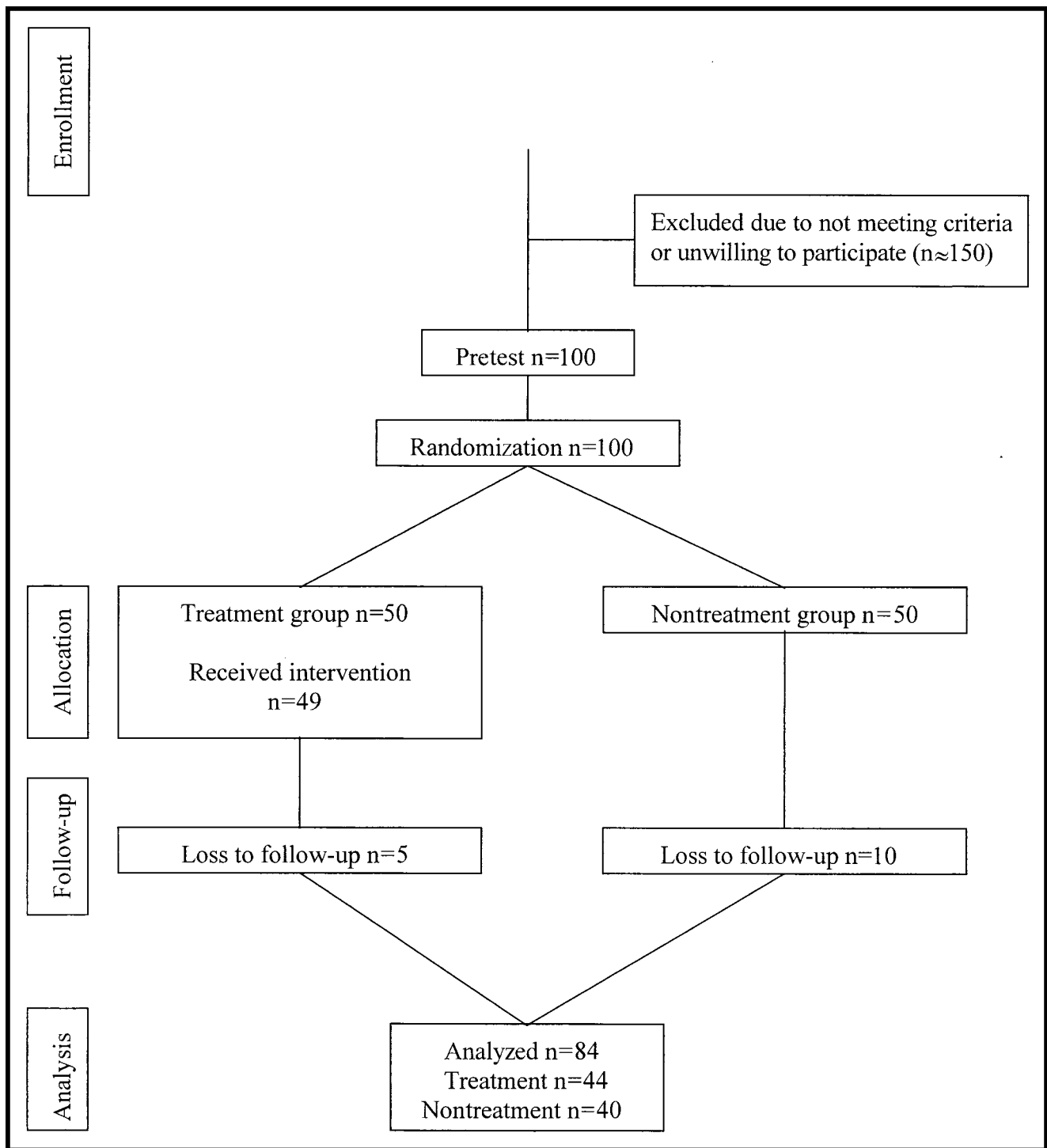


Figure.

Flow diagram of subject progress through a randomized controlled trial of physical therapist-supervised intervention versus no intervention other than written instructions in the early period following arthroscopic partial meniscectomy.

avoid patients receiving extended physical therapist intervention if it was of no benefit to them or to withhold treatment if treatment was appearing effective). Results from the interim analysis led to termination of data collection prior to reaching this target sample size.

Subjects were identified from patients recovering from knee arthroscopic partial meniscectomy at 4 National Health Service (NHS) hospitals and 3 private hospitals in the East London area over an 18-month period. Twelve orthopedic surgeons referred their patients for the

Table 1.

Baseline Characteristics for the Control and Intervention Groups

Variable	Control Group				Intervention Group			
	N	\bar{X}	SD	Range	N	\bar{X}	SD	Range
Age (y)	41	41	9	23 to 58	45	38	8	21 to 58
Height (cm)	41	174	9	157 to 192	45	176	7	157 to 192
Mass (kg)	41	84	16	54 to 123	45	80	13	57 to 110
Sex	35 male, 6 female				39 male, 6 female			
No. of days absent from work prior to surgery	40	2	2	1 to 7	40	64	268	0 to 1,600
Duration of injury (y)	39	2.4	5.0	0.5 d to 25.7 y	45	1.7	2.6	0.5 d to 14.2 y
Period from surgery to pretest measurement (d)	41	6	3	2 to 10	45	5	2	2 to 9
Passive knee flexion (difference between injured and uninjured knees) (°)	41	39	19	5 to 93	45	44	27	0 to 110
Suprapatellar knee girth (difference between injured and uninjured knees) (cm)	41	1.3	1.2	-1.0 to 4.0	45	1.4	1.0	-1.5 to 3.5
Injured side	Left=13, right=28				Left=22, right=23			
Meniscus involved	Medial=30 Lateral=9 Medial and lateral=1 Not reported=1				Medial=34 Lateral=10 Medial and lateral=1			

study. Subjects were deemed suitable for inclusion if they were between 18 and 60 years of age and underwent an uncomplicated arthroscopic partial meniscectomy. Subjects were excluded if they had any concurrent injuries to their contralateral lower extremity that required medical attention, if they had any neurological disorders affecting their lower extremities, or if they were expecting surgery within 6 months following their arthroscopy. Prior to the surgery in the private hospitals and within the first 48 hours following surgery in the NHS hospitals, approximately 250 suitable subjects were approached by one of the authors (PCG) and were given a written and verbal explanation of the study and invited to volunteer for participation. One hundred patients agreed to take part and signed an informed consent form prior to study participation. Fourteen patients did not return for follow-up testing, leaving 86 subjects for the final analysis.

After initial testing, subjects were assigned to 1 of 2 groups—a group who received physical therapy from a standardized protocol 3 times a week for 6 weeks (intervention group) and a group who did not receive physical therapy (control group)—using block randomization stratified by treatment site (Figure). Block randomization was used to keep a balance in the number of subjects in each group throughout the study. Blocks of 4 and 6 subjects were used in a random order so that randomization was not predictable. Stratified randomization was done for each of the potential treatment sites in an effort to keep the number of subjects (intervention

and control groups) balanced among the treatment sites.

The subject characteristics are presented in Table 1. The groups were very similar for all characteristics. The number of days absent from work prior to surgery contained an outlying value of 1,600 days in the intervention group, but no difference was found between the intervention and control groups, either with or without this value.

Testing

The target date for the pretest measurement was 4 days after meniscectomy. We believed this target date was realistic in terms of contacting patients and arranging appointments. This target date also was practical because the compression bandage prescribed by all the surgeons postoperatively remained on the knee for a minimum of 48 hours after surgery. During the first session, informed written consent was obtained. The following tests and measures also were administered: Hughston Clinic knee self-assessment questionnaire,¹⁹ self-assessed quality of life using the SF-36²⁰ and EuroQol EQ-5D (EQ-5D)²¹ questionnaires, passive knee flexion and extension ROM, and knee circumference and kinematic analysis of knee function during level walking and stair use. Two examiners who were blinded to group assignment were involved in each test, with at least one examiner being a physical therapist.

Passive knee flexion and extension and knee circumference were considered representative of measurements used in the clinic and included in order to determine differences between the 2 groups at baseline only. Biomechanical measures of kinematics of the knee while walking and ascending and descending stairs were included as a sensitive measure of knee angle during simple functional tasks. Self-assessed knee function gave a patient perspective on knee performance during activities of daily living. Use of quality-of-life measures, we believe, allowed us to obtain an extra dimension for analysis. Such generic outcomes included anxiety and depression as well as emotional health and vitality and have the potential of being able to measure the side effects or complications of treatment.²² Quality-of-life scores also can be combined with cost data to enable economic evaluation of health care.²¹ We believed that these outcomes represented important clinical and patient-orientated problems and would be helpful in detecting differences between the 2 groups.

The Hughston Clinic questionnaire was used to evaluate the subjects' self-assessment of their knee condition.¹⁹ This questionnaire consists of 28 questions in which the subject is asked to respond by placing a mark on a 10-cm visual analog scale (VAS). This questionnaire was chosen because: (1) it includes a continuous measure as opposed to an ordinal system²³; (2) it can be used to characterize most forms of knee function (from simpler, less stressful tasks such as turning over in bed to more complex and relatively stressful tasks such as pivoting while running); (3) it provides a measure of pain, swelling, and other complaints common in, and important to, patients with injured knees; (4) patients find it easy to understand and complete relative to other questionnaires¹⁹; (5) it is sensitive to clinically meaningful change;²⁴ and (6) its reliability and construct and content validity for patients with knee injuries have been exhibited.^{24,25}

In scoring the VAS, where the subject's mark bisected the horizontal line connecting 2 descriptors reflecting what was measured, the distance to the nearest 0.5 cm was measured from the left end of the scale. When values were between 0.0 and 0.5, they were always rounded up. Rounding was done in this fashion to ensure consistency among examiners of the data. No attempt was made to determine the location of the knee pain that led to a subject's responses. Ten of the 28 questions had 2 alternative marking options. For questions in which the subject responded by marking the box for "not attempted because of my knee injury," a value of 10 was given. For questions in which the subject responded by marking the box for "not attempted because of other reasons besides my knee injury," the question was deleted from the analysis. We did not have a policy for

assessing the validity of data for the questionnaire where there were fewer than 18 responses because, in our study, the minimum number of responses was 20. The final score was calculated by aggregating the scores of the questions answered and converting to a percentage of a maximum possible score for the questions answered. An uninjured knee would have a score of 0%.

The SF-36 is a widely used measure of health-related quality of life. It has been found satisfactory in terms of ease of use and acceptability to patients,²² and there is evidence of construct validity and convergent validity compared with the Western Ontario and McMaster University Osteoarthritis Index (WOMAC).²² For patients with knee osteoarthritis and rheumatoid arthritis, the SF-36 was found to be more responsive to change than a condition-specific measure (ie, WOMAC).²² It has been used in studies in which health-related quality of life was assessed in patients with knee problems²⁶ and in patients with partial meniscectomy.¹⁴ The SF-36 consists of 36 questions relating to 8 dimensions of health. An algorithm has been produced allowing mapping of results from this questionnaire onto a new SF-6D questionnaire for the construction of a preference-based single index of health status.²⁷ The result is a score from 0 to 1.0, where 1.0 equates to perfect health. We chose to analyze quality of life using the SF-36 in the single index form because: (1) it produces a single index allowing easier analysis, (2) it possibly has increased sensitivity over other single index measures of quality of life due to the richness and sensitivity of the original SF-36,²⁸ and (3) it has been suggested that any greater sensitivity would be most likely in people with mild to moderate health problems and in those expected to experience comparatively small changes, or where small differences are expected between interventions such as in the subjects in our study.²⁸

The EQ-5D is a generic instrument for describing and evaluating health-related quality of life. It was designed to be used for economic analysis (cost-utility analysis) representing the cost per quality-adjusted life year (QALY) of a technology and to complement other health-related quality-of-life measures such as the SF-36.²¹ The EQ-5D has been used with patients with rheumatoid arthritis affecting their knees,²⁹ and there is evidence that it has moderate construct validity (Spearman $\rho = .71$) and reliability (intraclass correlation coefficient = .70) when used with patients ($N = 82$) with osteoarthritis affecting their knees.³⁰ Brazier and colleagues²² suggested that it should be used for patients following knee surgery; however, it has not been validated for use with patients following arthroscopic partial meniscectomy. We included the EQ-5D in our study because it has been used with patients who have knee problems and because it, in our opinion, is widely

accepted as an easy-to-use tool for measuring the relative cost-effectiveness of an intervention. Our original intent in this study was to assess the cost-effectiveness of the 2 interventions in terms of cost per QALY gained.

Limits of passive knee motion were measured with the subjects lying supine and using a manual goniometer as routinely used in the clinics where our subjects were seen. The knee was passively flexed as far as the joint would allow or according to a subject's tolerance of pain. The goniometer was aligned with the greater trochanter and lateral malleolus while the knee angle was recorded. Passive knee extension was measured with the subject positioned supine with a block placed under the subject's heel to allow for hyperextension or used to support the thigh if extension was limited. Goniometer alignment was the same as for the flexion test. Passive ROM testing was included as a baseline characteristic for comparing the control and intervention groups prior to intervention. Knee ROM was measured by 1 of 2 qualified clinicians. Intrarater reliability analysis of measurements of knee ROM taken by the 2 examiners for the uninjured leg in early participants in the study demonstrated least significant difference (LSD)³¹ values of 4 degrees (PCG) and 6 degrees (MK) for extension and 6 degrees (PCG) and 9 degrees (MK) for flexion.

Knee circumference also was measured with the subjects in the supine position. Each subject's heel was placed on a block in full passive extension to standardize the knee angle. For subjects who were unable to achieve full passive extension, the knee angle was recorded and the posttest knee circumference measurement was obtained in the same position as in the pretest. The uninjured knee was measured in the same position as the injured knee. Measurements were taken 1 cm above the superior border of the patella because such measurements have been shown to be more precise and to correlate better with the quantity of synovial fluid aspirated than measurements obtained at the mid-patella level.³² Intrarater reliability analysis showed LSD values for girth tests for the 2 examiners (MK and PCG) were 1.22 and 0.58 cm, respectively.

Knee ROM in the sagittal plane during the stance phase of walking and while ascending and descending stairs was measured with the Kinemetrix infrared-based 3-dimensional (3D) camera system using 3 cameras.[†] A force platform (model 4020H[‡]) was used for these measurements to detect the initiation and termination of the stance phase. Although 3D accuracy of the Kinemetrix system has been shown,³³ the reliability and validity of the measurements obtained with this system

were not assessed prior to this study. Neither interrater nor intrarater reliability of marker placement over anatomical areas was assessed. Reflective markers were placed over the greater trochanter, the middle of the lateral joint line of the knee, the lateral malleolus, and the base of the fifth metatarsal to produce an animated stick figure from which sagittal-plane knee angles were calculated. For each subject, mean knee angle curves during stance phase (heel-strike to toe-off) were calculated from 3 trials of each task. Subjects walked along an 8-m walkway and ascended and descended a staircase in bare feet and at their own pace. The staircase consisted of 4 standardized steps with a tread length of 28.5 cm and a rise height of 18 cm.

The Hughston Clinic questionnaire also was completed 3 weeks after surgery. This was done for 2 reasons. First, for subjects in the intervention group, knee extensor resistance exercise weight at 3 weeks after surgery was determined relative to their Hughston Clinic questionnaire scores. These values were then compared at each of the 3 treatment sites to evaluate whether the therapists were being equally aggressive in their treatment. For example, we divided the resistance weight used for the knee extensor exercise by the Hughston Clinic questionnaire scores to estimate how aggressive each therapist was being in his or her treatment. The data were used to instruct the therapists in order to ensure consistency of treatment aggressiveness. Second, testing at 3 weeks allowed for comparison of the 2 groups during the early period of the intervention.

Subjects returned for repeat testing 6 weeks after the pretest (target date for the pretest was 4 days after meniscectomy). New tests administered at the 6-week follow-up were the FORS questionnaire³⁴ and single-leg vertical³⁵ and horizontal³⁶ hop tests. The single-leg vertical hop test was done only during the 6-week follow-up because subjects were unable to perform the test during the first week after surgery. The FORS questionnaire measures the amount of stress the knee encounters in the workplace.³⁴ In a randomized controlled trial, the FORS questionnaire was compared with an alternative questionnaire, which used job titles to rate occupational activity. The FORS questionnaire was used to discriminate between perceived activity at work according to job title and actual stress to the knee experienced.³⁴ This discrimination allows an added dimension to our understanding when we consider the time it takes to return to work following surgery. The FORS questionnaire consists of 7 questions and uses criteria for rating the frequency, intensity, and duration of various tasks undertaken in the workplace. The questionnaire is scored between 0 and 60, with 0 representing "no stress on the knee at work" and 60 representing "a very stressful occupation." We combined this measurement with the

[†] MIE Medical Research, Leeds, United Kingdom.

[‡] Bertec Corp, 6185 Huntley Rd, Columbus, OH 43229.

number of days taken to return to work and expressed it as a ratio in order to weight the days taken to return to work according to the stressfulness of the subject's work on the knee.

Subjects performed the single-leg horizontal and vertical hop tests, with the vertical hop test being done last because we considered it the most strenuous test and we were concerned that it might affect the subjects' performance in the other tests. We used the single-leg hop tests because they have been found to yield relatively reliable data³⁶⁻³⁹ and representative measurements of knee function^{35,36,40} during the postoperative period. Both tests were performed with bare feet with the test leg landing on a sponge mat. For both hop tests, the limb on the side without injury was tested first, and subjects repeated maximum-effort jumps until there were 2 consecutive reductions in distance or height jumped. This method was used based on our belief that no further gains would be made through practice and that further reductions would occur due to pain or fatigue. Tests were considered successful if the subject landed on the test leg without losing balance. The trial with the maximum distance was used in later analysis. For the purpose of this analysis, only the more strenuous single-leg vertical hop test was used.

Subjects stood with bare feet on a sponge mat in a marked out rectangle to standardize the starting position. The subjects stood at a right angle to the wall and reached as high as they could with their feet flat on the floor. They then marked the wall with the tip of their chalked middle finger. This mark represented the baseline height. The subjects then hopped as high as they could, re-marking the wall at the highest point of the jump. The distance between the baseline height and the highest chalk mark was considered the maximum height jumped.

Training

All subjects received a standardized written home exercise program and advice sheet while they were in the hospital. The sheet format was an amalgamation of advice provided by the hospitals involved in the study and agreed on by the principal investigator (MCM) and the clinicians involved. The advice and exercises were explained by a physical therapist prior to each subject's discharge home. The sheet included information about the surgery and the recovery period and basic home exercises for the knee. Subjects were instructed to manage their pain and swelling with rest, elevation of the limb, and application of crushed ice or a packet of frozen vegetables to the knee for 15 minutes, 4 times per day. Ten repetitions of the exercises were done hourly for the first 3 days. Then static and inner-range (0°-45° of knee flexion) quadriceps femoris muscle strengthening

exercises, straight leg raises, hip flexion movements in a supine position, and knee flexion and circular hip movements in a long-sitting position were done 4 times per day until the subject's orthopedic review at 6 weeks postoperatively. Subjects in the control group received no other care during the intervention period.

Subjects assigned to the intervention group were asked to attend physical therapy sessions 3 times per week for the 6-week training period of the study. Sessions occurred in the outpatient physical therapy departments at 1 of 2 NHS hospitals (Mile End Hospital or Whipps Cross Hospital) or in a private hospital (Holly House Hospital) in the East London area.

The intervention was devised in collaboration with the senior therapists (MB and KS) who provided the treatment. It allowed for progression of the subjects according to their level of pain. The therapists asked the subjects to report their pain score (between 0 and 10, with 0 being "no pain" and 10 being "the worst pain ever experienced") during and following each exercise. The exercise was then revised (increased or decreased) according to whether the subjects' pain level fell above or below 3 out of 10, respectively. The 6-week intervention consisted of 3 sequential treatment periods of arbitrary duration, each with distinct general goals.

The first treatment period aimed at decreasing pain and swelling (using ice, ultrasound therapy, and deep friction massage) and increasing joint ROM (using joint mobilization). For every subject, an ice pack was applied anteriorly to the knee for 15 minutes after every treatment session. Ultrasound therapy was used only over arthroscopy scar sites and only if the tissues could not be made more mobile by friction massage such that ROM was increased, thus reducing pain. If pulsed ultrasound therapy was used, it was at a standardized 3 MHz for 1 to 2 minutes/10 cm² at an intensity of 0.5 W/cm² and recorded each session.⁴¹ Deep transverse friction massage was performed over the scar sites for 5 minutes on all subjects during the first session. Subsequent treatments were recorded and ceased when there was no palpable restriction of the scar tissue. Maitland techniques⁴² for assessment of patellofemoral and tibiofemoral mobility were performed on all subjects during the first session. Patellofemoral assessments included caudad, cephalad, medial, lateral, and combined motions of the patella. Tibiofemoral assessments included anterior, posterior, medial, lateral, and rotational movements of the tibia in relation to the femur. Treatment grades of I to IV in doses of 3 × 30 seconds were performed as needed based on the assessments. Treatment was continued and recorded until pain-free, full ROM was achieved or until the 18th treatment, whichever occurred sooner.

Table 3.Comparison of Pretest and Posttest Outcomes for the 3 Training Sites^a

Site and Test	Hughston Clinic Questionnaire Score			EQ-5D Questionnaire Score			Injured/Uninjured Limb Vertical Jump Height			Days Taken to Return to Work After Surgery/FORS Score		
	\bar{X}	SD	Range	\bar{X}	SD	Range	\bar{X}	SD	Range	\bar{X}	SD	Range
HHH pretest	58 (n=17)	14	10–70	0.50 (n=16)	0.25	0.06–0.80	NT	NT	NT	NT	NT	NT
HHH posttest	28 (n=17)	15	0–59	0.76 (n=16)	0.16	0.29–1.0	0.86 (n=12)	0.21	0.49–1.16	1.25 (n=15)	2.02	0.07–3
MEH pretest	59 (n=17)	14	31–83	0.55 (n=16)	0.22	0.06–0.81	NT	NT	NT	NT	NT	NT
MEH posttest	29 (n=17)	19	3–61	0.66 (n=17)	0.25	0.06–1.0	0.89 (n=17)	0.19	0.55–2	1.75 (n=15)	2.15	0.21–8.26
WCH pretest	59 (n=11)	19	40–100	0.64 (n=10)	0.16	0.4–1.0	NT	NT	NT	NT	NT	NT
WCH posttest	25 (n=11)	22	0–80	0.89 (n=9)	0.12	0.69–1.0	0.87 (n=11)	0.18	0.48–1.13	1.38 (n=10)	1.24	0.17–4.25

^a HHH=Holly House Hospital, MEH=Mile End Hospital, WCH=Whipps Cross Hospital, NT=not tested. Hughston Clinic questionnaire score scale is 0 to 100, with 0 being the score for a normal knee. Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) single index score scale is 0 to 100, with 100 being the score for normal health. EQ-5D questionnaire score scale is 0 to 1.0, with 1.0 being the score for normal health. FORS=Factor Occupational Rating System, possible range of scores=0–60, with 60 being the score for the occupation that is most taxing on the knee.

one continuous predictor produces the same results as that from an analysis of covariance.⁴³ A linear regression analysis was used to examine treatment differences in the 2 groups for each of the 2 normally distributed outcomes: (1) maximum-minimum knee angle during stair ascent; and (2) injured and uninjured limb vertical jump ratio. Relevant baseline scores were included in the analysis for maximum-minimum knee angle during stair ascent to adjust for differences in these measurements. The following outcomes were not normally distributed, and we therefore did not use an ordinary linear regression for those analyses: Hughston Clinic questionnaire scores, SF-36 scores, EQ-5D scores, and the number of days off work after surgery adjusted for the FORS questionnaire scores. We attempted to use mathematical transformations to satisfy the assumption of normality. We found the best transformations to achieve normality for the Hughston Clinic questionnaire scores, SF-36 scores, and EQ-5D scores were square root and square transformations, which would make interpretation of results difficult. Moreover, no suitable transformation was found for the outcome of number of days off work/FORS questionnaire scores. Therefore, a median regression analysis, which examines the difference in medians rather than means and does not require the assumption of normality, was used for these 3 outcomes.⁴⁴ The relevant baseline scores were included in the regression analysis for the Hughston Clinic questionnaire scores and EQ-5D scores to adjust for baseline differences.

The regression analyses as described were also used to determine whether the number of treatment sessions

attended by subjects influenced the outcome scores after adjustment for differences in baseline scores. Subjects in the intervention group were subgrouped into those attending 1 to 6 treatment sessions, those attending 7 to 12 treatment sessions, and those attending >12 treatment sessions. These grouping criteria were based on a simple division into 3 groups of the 18 sessions, the goal for the intervention group. A significance level of .05 was used to assess statistical significance. All analyses were carried out on an intention-to-treat basis using STATA statistical software (Release 7.0, 2001).[§]

Results

Baseline outcome measurements collected for both groups included Hughston Clinic questionnaire scores, SF-36 scores, EQ-5D scores, the difference between maximum and minimum knee angles during stance phase while ascending stairs, and the difference in end-range passive knee flexion angles between injured and noninjured limbs (Tab. 2). No differences were found between the 2 groups in these baseline characteristics.

Before the 2 main study groups were compared, the relative effectiveness of the supervised physical therapy at the different training sites was assessed (Tab. 3). No differences were noted among the 3 sites. These results indicate that treatment effectiveness was similar among the 3 sites. The components of the intervention are

[§] Stata Corp, College Station, TX 77840.

Table 4.

Variables Describing the Components of the Physical Therapy Program for the Intervention Group (N=44)

Variable	\bar{X}	SD	Range
No. of treatment sessions per subject	12	4	2–18
Total no. of minutes on bicycle ergometer (out of possible total of 180 min)	111	38	20–180
Treatment session where quadriceps femoris muscle exercise using ankle weights was first used	1	1	0–4
Treatment session where quadriceps femoris muscle exercise using knee extension machine was first used	3	3	0–13
Total no. of quadriceps femoris muscle exercise sessions using knee extension machine	8	5	0–16
Treatment session where hamstring muscle exercise using ankle weights was first used	1	2	0–9
Treatment session where hamstring muscle exercise using hamstring muscle curl machine was first used	3	4	0–13
Total number of exercise sessions using hamstring muscle curl machine	9	4	0–18

Table 5.

Results of Regression Analysis^a

Variable	N	Mean Difference	95% CI	P ⁱ
Maximum-minimum knee angle during stair ascent ^b (°)	72 ^c	−1.47	−4.26 to 1.31	.295
Injured/uninjured limb vertical jump ratio	77 ^d	0.06	−0.02 to 0.14	.165
Hughston Clinic questionnaire score ^b	84 ^e	4.70	−3.98 to 13.32	.286
SF-36 score ^b	83 ^f	0.01	−0.02 to 0.05	.445
EQ-5D score ^b	80 ^g	0.00	−0.06 to 0.06	>.5
No. of days taken to return to work after surgery/FORS score	79 ^h	0.03	−0.56 to 0.61	>.5

^a One subject in each group was unable to perform the vertical jump test because of the inability to hop on his or her injured knee due to pain, and 2 subjects in the intervention group and 4 subjects in the control group did not complete the test because we had not included it as an outcome measure at that time. Difficulties obtaining kinematic data during stair ascent resulted in the loss of data for 7 subjects in each group. Some subjects incorrectly filled in the questionnaires. Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) single index score scale is 0 to 1.0, with 1.0 being the score for normal health. Hughston Clinic questionnaire score scale is 0 to 100, with 0 being the score for a normal knee. EQ-5D questionnaire score scale is 0 to 1.0, with 1.0 being the score for normal health. FORS=Factor Occupational Rating System, possible range of scores=0–60, with 60 being the score for the occupation that is most taxing on the knee.

^b These analyses are adjusted for differences in relevant baseline (pretest) measurements (eg, median difference in Hughston Clinic questionnaire scores examined between intervention and control groups after adjusting for baseline measurements of Hughston Clinic questionnaire scores).

^c Control group=34, intervention group=38.

^d Control group=40, intervention group=43.

^e Control group=36, intervention group=41.

^f Control group=40, intervention group=44.

^g Control group=40, intervention group=40.

^h Control group=39, intervention group=40.

ⁱ The P values were obtained from regression analysis based on a *t* statistic.

presented in Table 4 in order to display some of the key components of the protocol used in the study.

Initially, we compared the outcomes between the 2 groups with the results presented in Table 5. The results were adjusted for differences in relevant baseline measurements of the outcomes because they were found to be strong predictors of the outcomes. The other baseline characteristics between the 2 groups were similar, as shown in Tables 1 and 2, and therefore did not require accounting for in the analysis of outcomes. The magnitude of the differences in the means and medians between the 2 groups 6 weeks after surgery was consistently small. The mean differences between the 2 groups in knee angle excursion (maximum-minimum knee angle) during stair ascent and injured and uninjured limb vertical jump ratio (and 95% confidence interval [CI]) were 1.5 degrees (95% CI: −4.3° to 1.3°) and 0.06 (95% CI: −0.02 to 0.14), respectively. Results of measures of quality of life showed that there were differences between groups of 0.01 (95% CI: −0.02 to 0.05) in SF-36 medians and 0.00 (95% CI: −0.06 to 0.06) in EQ-5D medians. The differences between the 2 groups in their medians for knee function measured using the Hughston Clinic questionnaire scores and in the number of days taken to return to work weighted for the amount of stress to the knee at work (FORS questionnaire scores) were 4.70 (95% CI: −3.98 to 13.32) and 0.03 (95% CI: −0.56 to 0.61), respectively. No differences were observed between the 2 groups for any of the outcomes.

The conclusions reached by using an ordinary linear regression analysis with a square transformation for Hughston Clinic questionnaire scores and square root transformation for EQ-5D scores were similar to those obtained from the median regression analyses. There was no difference in the patterns of missing data between the 2 groups, and missing outcome data for some of the subjects did not create any differences in miss-

ing data for the baseline characteristics between the 2 groups. We then investigated the influence of the number of treatment sessions received on each outcome and did not observe any effects.

Discussion

This study contained the largest sample analyzed to date comparing the benefits of supervised intervention provided by physical therapists plus verbal and written advice with written and verbal advice only following an uncomplicated arthroscopic partial meniscectomy. No differences between groups existed for any of the outcome measures observed. Additionally, the groups did not exhibit any differences that we considered clinically meaningful. The demographic characteristics in terms of age, sex, and injury type were similar to those of previous randomized controlled trials,^{15,16,17} except for that of Mofet et al,¹¹ who examined only male patients with medial meniscus tears. The main differences between our study and previous studies were the outcome measures used.

In our attempt to report patient-relevant outcomes, we examined quality of life using the SF-36. Roos et al¹⁴ reported improvements in quality of life based on the vitality, mental health, pain, physical function, and role function subscales of the SF-36 questionnaire obtained 14.4 weeks postoperatively compared with scores obtained preoperatively. However, physical disability, pain, and problems with work or recreational activities still existed at 14.4 weeks when compared with a reference sample from the Swedish general population. Unfortunately, this report lacks details of the exact amount of deficit but states that it was a statistically significant difference ($P < .05$). To our knowledge, no other studies have used the EQ-5D to evaluate changes in quality of life after arthroscopic meniscectomy. The SF-36 and the EQ-5D showed no differences between groups.

Improvements in mean knee angle excursion (maximum-minimum knee angle) during stair ascent were evident between 1 and 6 weeks postoperatively for both groups. Mean knee angle excursion increased from 42 degrees (SD=6, range=20–54) preoperatively to 49 degrees (SD=6, range=32–58) postoperatively for the intervention group and from 40 degrees (SD=8, range=21–54) preoperatively to 51 degrees (SD=5, range=39–61) postoperatively for the control group. At 6 weeks after surgery, however, no differences were found between the 2 groups. Durand et al¹⁰ reported no differences in knee ROM during stair ascent and descent for a group of subjects with injuries compared with a group of subjects without injuries, but they reported a decrease in knee flexion between the groups during the mid-stance phase of level walking 8 weeks postoperatively. Only a small sample (N=17) was studied by Durand et al,¹⁰ and no

reference was made as to whether the decrease in knee angle was clinically meaningful. Walking and stair ascent and descent may not be of sufficient vigor to elicit functional deficits in this population at this point in time after surgery. Because of this, we added the more strenuous task of the vertical jump to determine outcome at 6 weeks after surgery in our study.

The FORS measure is an occupational rating scale that includes 7 factors that place varying amounts of load on the lower extremity.³⁴ The FORS questionnaire is graded from 0 to 60, and grades are based on the intensity, frequency, and duration required of each factor on a daily basis. The second component includes an assessment of any change in work activities. Vervest et al¹⁷ reported that both the intervention and control groups increased the stress placed on the knee at work from day 7 to day 28 as measured using the occupational rating scale scores. However, no differences in the FORS score existed between the 2 groups at any point during the study. The results are difficult to interpret without reporting whether the increase in scores was due to the subjects' knee condition or to changing occupation. Using the occupational rating scale score to indicate the stressfulness of patients' occupation on their knees and combining it with the number of days taken to return to work, we believe, allows a more valid assessment of recovery. We found no differences between groups for the number of days taken to return to work divided by the FORS questionnaire score. We suspect that other determinants such as limited sick leave allocated by the employer, self-employment, and being unemployed meant that only in a few cases was the restoration of knee function the true reason for returning to work. These results highlight the limitation of using return to work alone as an outcome measure for studies of partial meniscectomy recovery.

Vervest et al¹⁷ found that the group who received supervised physical therapy showed greater improvement than the home exercise group over the intervention period in terms of single-leg horizontal and vertical jumps. At the 28-day follow-up, the results for mean vertical and horizontal jumps between the groups did not differ. The greater increase for the group who received supervised physical therapy could be accounted for by the discrepancy in favor of the therapy groups in the baseline results. In our investigation, we did not include baseline measurements for jumping because we thought it to be too soon after surgery (5 days). During the pretest measurements, many subjects exhibited knee effusion and pain, and they were still ambulating with crutches and had not been ascending or descending stairs using a step-through gait pattern without crutches. Our results showed that when comparing the injured lower extremity with the uninjured lower extremity in

terms of a ratio for jumping, no differences were found between groups. The possibility exists that the groups differed in preintervention knee function and that we failed to detect differences in improvement. We suspect that this did not occur due to the similar pretest performance in the groups in other measures of function (eg, Hughston Clinic questionnaire scores and knee kinematics during stair climbing).

From previous randomized controlled trials of supervised rehabilitation compared with home exercise programs after arthroscopic partial meniscectomy, we believe a trend is emerging suggesting that there is no benefit of a supervised program of rehabilitation over verbal and written advice. We believe this observation is in line with other randomized controlled trials for other knee problems, including anterior cruciate ligament reconstruction.^{45,46}

Comparisons with previous studies are limited because of a lack of standardization of intervention for the supervised physical therapy protocol and written and verbal home exercises. This lack of standardization, including different lengths of intervention, number of treatment sessions (range=3.1–13.5), and range of interventions, suggests there is little consensus on which intervention, if any, is the best.¹⁸ In our study, the mean number of treatment sessions was 12, although it was our aim to treat subjects in the intervention group 18 times to ensure that a treatment effect had occurred. Because this number of treatment sessions plus written and verbal advice did not improve outcome over advice alone, it is unlikely that a rehabilitation program containing fewer treatment sessions would improve outcome further. Our results showed a large variation in the number of treatment sessions attended in the intervention group. To eliminate the risk of low numbers of treatment sessions affecting the efficacy of the intervention, subjects were split into groups according to the number of treatment sessions attended (1–6, 7–12, and >12). No relationship was found between outcome and the number of treatment sessions attended. We were unable to question those who did not attend the full 18 treatment sessions (due to blinding), and therefore we cannot comment as to reasons for these absences. We doubt that the number of treatment sessions was insufficient in this program.

The intervention was standardized as much as possible without it being impracticable to follow. The intervention was based on guidelines of phasic approaches,^{47–49} where treatments can be defined into early, middle, and late phases. Each phase has specific goals (eg, in the early phase, the goal is to reduce inflammation to decrease pain and increase ROM), and the program cannot be progressed to the next phase until the goals

for each phase have been met (eg, cannot strengthen through full ROM until inflammation has been reduced). The therapists at the different sites were trained in the use of the protocol and were given guidelines to follow to progress the subjects' treatments. Therapists at all of the sites were regularly observed (by the principal investigator [MCM]) in an effort to ensure there was standardization of the intervention. We believe we can state with confidence that the lack of treatment effectiveness in this study was unlikely to have been due to an inadequate intervention or its poor application.

Although detailed and standardized reports were kept for the intervention group, records or diaries were not kept for the activities of the control group during the 6-week intervention period. Additionally, it is possible that the control group sought physical therapy outside of the study, although we suspect that even if this did occur, it was probably not of the frequency or intensity of those receiving intervention in the study. Subjects in both groups were asked if they had received any other form of intervention. None of the subjects in the control group sought other interventions for their knee, but no records of other activities such as attendance at a gym or sports played were taken.

Moffet et al¹¹ suggested that a Hawthorne effect (ie, the presence of an observer affecting the behavior of those being observed) may have been responsible for the differences in knee extensor work between the intervention and control groups at 3 weeks postsurgery in their study. A Hawthorne effect also could have been responsible for some of the improvement in the control group in our study who, knowing that they would receive no other intervention, followed the written and verbal instructions more diligently than subjects in the intervention group. Knowing that they were being compared with a group being treated by physical therapists, they may have sought rehabilitation at their local gym or returned to routine activities of daily living sooner than they would have otherwise. Tighter control over the activities performed by subjects in the control group may have resulted in a different outcome, although we felt that this would not have accurately reflected real life. Diaries to record daily activities for subjects in both groups would have been useful to enable comparisons.

The large range of postsurgical test dates at which outcomes have been measured, where no differences have been observed between intervention and control groups, affirms the speed of patient recovery following an arthroscopic partial meniscectomy. In previous trials,^{11,15–17} outcomes have been measured at 1, 2, 3, 4, 6, and 8 weeks after surgery. We examined recovery in the early period following minimally invasive surgery. Follow-up reports of good postoperative function, radio-

logical examination, and lack of recurrent morbidity according to surgeons' reports⁵⁰⁻⁵² suggest that the potential for finding long-term differences between the groups we studied is unlikely.

Conclusion

In a randomized controlled trial of physical therapist-supervised intervention plus written and verbal instructions compared with written and verbal instructions alone in the early period after arthroscopic partial meniscectomy, no differences were found at 6 weeks after surgery for any of the outcomes examined. Both the intervention and control groups improved similarly overall, revealing no benefit in receiving a mean of 12 standardized treatment sessions postsurgery over written and verbal advice. We therefore conclude that for an uncomplicated arthroscopic partial meniscectomy, routine physical therapy intervention is not indicated.

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